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Advanced Techniques for Incineration of Municipal Solid Wastes

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ADVANCED TECHNIQUES FOR INCINERATION OF MUNICIPAL SOLID WASTES

U.S. ENVIRONMENTAL PROTECTION AGENCY

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The author describes a pyrolysis project in New York State. A pyrolysis system was designed to process 75 TPD that can convert municipal solid waste into a clean, inert residue without causing air or water pollution. In order to test, it is necessary, to obtain economic, technical, and operational data to evaluate the system and provide a basis for assessing the potential of larger-scale operations.

The project was set up in three phases: The primary objective of Phase I was to design, install, and operate those major subsystem components of the entire system necessary to demonstrage that the basic concept is a viable one and that an inert residue can be produced by converting the noncombustible portions of the refuse into a molten slag. Phase II involves the installation of the remaining equipment for the exhaust gas pollution control subsystems, startup and integration of the entire equipment system, and Phase II testing. The project is currently at this Point. Phase III will involve gathering economic and technical data during sustained 24-hour operations.

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ADVANCED TECHNIQUES

FOR INCINERATION OF MUNICIPAL SOLID WASTES

A Division of Processing and Disposal
Open File Report (SW-38d.of)
written by
Jack DeMarco, Deputy Director

U.S. ENVIRONMENTAL PROTECTION AGENCY

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ADVANCED TECHNIQUES FOR INCINERATION OF MUNICIPAL SOLID WASTES

Jack DeMarco*

Introduction

Although communities have long used incineration in trying to cope with their solid waste problems, there has been a fair amount of dissatisfaction with the results of the process. Much of it is well justified and, unfortunately, is still present, but the days of the belching smokestack are numbered. New standards at the local, State, and Federal level no longer allow for procrastination in improving our environment. The upper limits of good technology are now being set as implementation requirements.

Previous speakers have presented current thinking and data on emissions, control techniques, and incinerator maintenance and operation as they relate to air pollution control. The best technology currently available must be put into use without delay. In addition, new concepts must be demonstrated, proven effective, and then put into operation in our solid waste management activities. I will discuss two projects EPA is supporting in its efforts to demonstrate advanced techniques for processing the ever-growing amounts of solid waste that are generated in our country.

Pyrolysis

One of the techniques that we feel has good potential for successfully incinerating municipal solid waste is pyrolysis. Although the concept of pyrolysis is by no means new, the application of it in managing our solid waste problems can be considered one of the advanced techniques under investigation today. A few systems are reportedly commercially available now but, in our view, data supporting claims made for them are somewhat

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*Deputy Director, Processing and Disposal Division, Office of Solid Waste Management Programs, U.S. Environmental Protection Agency. Presented in St. Louis on May 23, 1972, at the 72nd National Meeting of the American Institute of Chemical Engineers.

lacking. This does not mean that the potential is not there. In my opinion, it simply means that we need to show what can actually be accomplished to reduce the volume of solid waste, what improvements on environmental emissions can be achieved while doing so, and at what total cost to the operation. If anyone has such data on operations at a reasonable scale and is willing to share the information, we will be more than happy to receive it. The following descriptions are of two of our projects directed at obtaining such data for use in the field of solid waste management.

We have a pyrolysis project in New York State that is supported by Erie County, New York, Torrax Corporation, Carborundum Company, A E. Anderson Construction Corporation, American Gas Association, the New York State Department of Environmental Conservation, and the Office of Solid Waste Management Programs of the Federal Environmental Protection Agency.

We hope to demonstrate a pyrolysis system designed to process 75 TPD that can convert municipal solid waste into a clean, inert residue without causing air or water pollution. In order to do this, we need to obtain economic, technical, and operational data to evaluate the system and provide a basis for assessing the potential of larger-scale operations across the nation.

The project was set up in three phases: The primary objective of Phase I was to design, install, and operate those major subsystem components of the entire system necessary to demonstrate that the basic concept is a viable one and that an inert residue can be produced by converting the noncombustible portions of the refuse into a molten slag.

Phase II involves the installation of the remaining equipment for the exhaust gas pollution control subsystems, startup and integration of the entire equipment system, and Phase II testing. We are currently at this point in the project.

Phase III will involve gathering economic and technical data during sustained 24-hour operations. Erie County personnel will be trained, final reports issued, and the facility turned over to Erie County at the close of the project.

The following description of the concept and how the process works can be better understood by referring to Figure 1, which is a simplified schematic of the system.

The system is designed to convert mixed municipal refuse--including metal, glass, and garbage--into an inert residue by completely consuming combustible material and melting noncombustible material at temperatures up to 3,000 F. The refuse is processed without any sorting or pretreatment.

The major subsystems in the entire process are: (1) a super blast heater; (2) a gasifier; (3) an igniter (more commonly called a secondary combustion chamber); (4) a gas cooler which can be any means conventionally used to cool hot exhaust gases (in the Erie County project, it is a waste heat boiler); (5) an air pollution control device (a glass fabric type dust collector is being tried in Erie County.)

The super blast heater, which provides the high temperature air required in the system, is an all-refractory, shell-tube heat exchanger. Ambient air is blown through the inside of special refractory tubes and is heated from the outside by hot combustion products. The hot combustion gases flow around the tubes and up through a baffle system, thereby causing

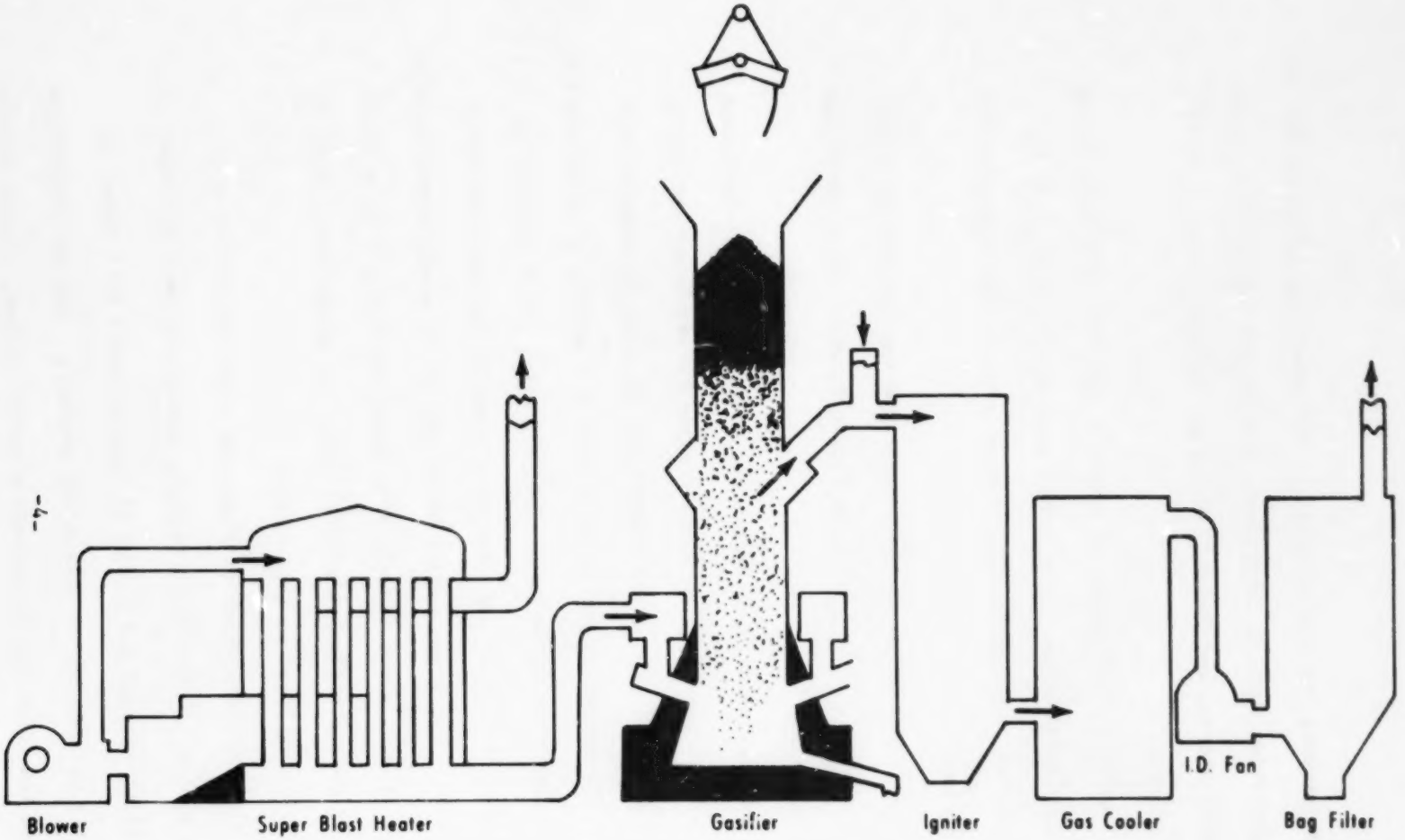

Figure 1: Simplified schematic of the Torrax system.

an efficient transfer of heat to the air that is to be delivered to the gasifier. Since external heating is applied to this air, the oxygen level is not depleted and 2,000-2,200 F air is delivered to the base of the gasifier through tuyeres. The oxygen in the high temperature air then combines with the carbon in the pyrolyzed waste at the base of the gasifier to generate temperatures high enough to produce a molten slag.

Refuse is periodically charged into the top of the gasifier by a crane and clam-shell bucket, and the column of solid waste acts as an air seal. The column settles slowly down the gasifier as pyrolyzation occurs in the upper part of the gasifier, and slagging takes place at the base. Pyrolyzation of the readily combustible materials occurs due to the controlled deficiency of preheated air supplied to the total waste column present in the gasifier. These easily combustible materials are pyrolyzed before they reach the high temperature zone at the base of the gasifier.

Difficult-to-burn or noncombustible materials that reach the bottom of the system are burned or liquified to form a molten slag, which is tapped and fritted to produce a black, glassy-like aggregate residue. "Average" refuse is expected to undergo a 95 percent reduction in volume in the Torrax System. Eventually, this residue may have by-product value as an aggregate or a source of raw material for crude metal, glass, and blown fibrous products. The scope of the Erie County project does not include any by-product studies.

The combustible gases generated from the pyrolyzation of the organic matter are drawn off under negative pressure through an annular header in

the upper stack of the gasifier. This pressure is induced by the I.D. Fan in Figure 1. These evolved gases are expected to consist chiefly of carbon monoxide, methane, and a variety of hydrocarbons, water vapor, and nitrogen. The refuse column tends to act as a preliminary filter to inhibit the carry-over of particulates with these gases into the secondary combustion chamber (igniter). The hot gases passing through the refuse column transfer a large part of their sensible heat into the refuse.

The evolved gases are expected to range from 800 F to 900 F as they are drawn into the secondary combustion chamber where complete combustion occurs. It is important to note, however that the gas stream leaving the igniter contains less than 2 percent excess air. This compares very favorably with conventional incineration systems that may contain 75 to 100 times as much excess air. The lower volume of downstream exhaust gases allows for relatively smaller size air pollution control equipment.

A torrential mixing pattern is imposed on the gases as they enter the secondary combustion chamber to promote thorough combustion. Under steady state conditions, the chamber is expected to operate at about 2,000 F to 2,400 F.

The hot gaseous products of combustion are then drawn from the secondary combustion chamber through the rest of the emission control subsystems to be cooled and cleaned before entering the atmosphere.

A dry emission control system, which utilizes a waste heat boiler for the gas cooler subsystem, is being used. It is designed to produce

about 20,000 lb/hr of process-type saturated steam at 150 psig that will be condensed and recycled. No secondary use is being or will be made of the steam produced.

The hot gases from the secondary combustion chamber will be cooled to 500 F-525 F before being introduced into the bag house, which is a pressure type to inhibit any leakage and condensation problems. There are additional safeguards incorporated into the system to preclude any potential condensation problems. Approximately 40,000 ACFM at about 450 F will leave the bag house.

In summary, we hope to demonstrate:

1. A high-temperature combustion process that results in very high-volume reduction;

2. The potential of the system to convert solid waste into energy;

3. That a clean, inert residue can be produced with by-product possibilities;

4. That a combustion process can be operated with few moving parts;

5. That a relatively small-size plant can be designed having a capacity comparable to larger conventional plants;

6. An advanced technique that is economically competitive with advanced conventional incinerators of today.

We have not yet determined the system's economics from actual operating data, but such data will be collected in Phase III, which will take place late this summer. Our projections, to date, are based on engineering estimates; preliminary data indicate that costs could be $10 to $12 per ton without any revenue from the steam and residue produced.

We are hopeful that actual full scale data may prove to be even better than our estimates.

The facility has been operated eight hours a day for a two-week period to prove its reliability, at least under these conditions. During the test, the unsorted solid waste was very effectively converted to slag. The average burning rate achieved was 5.4 tons per hour (43 tons/8 hours), considerably more than the 3-ton-per-hour rate originally expected. The higher burning capacity caused more steam to be generated than the 19,500 lbs per hour anticipated, and this caused temperature problems in the bag filters. Both the waste heat boiler and air pollution control system will probably be modified for the higher throughput to protect them from problems caused by undersized equipment.

The volume reduction attained was approximately 95 percent of the total unsorted waste charged to the unit. The facility has not been tested for stack emissions but will be evaluated during Phase III for its ability to meet the new Federal particulate emission standards--0.08 grains/SCF @ 12% CO_2.

Use of Refuse as Supplementary Fuel in Boiler Furnaces

Another project that we feel has a good deal of potential deals with the concept of using solid waste as supplementary fuel in boiler furnaces. Although the idea of using solid waste to produce energy is not new, no widespread, large-scale application has ever received any real impetus. The project is designed to use solid waste to produce energy at electric utility plants across the nation. If successful, it will:

1. Provide an economic method for municipalities to manage their solid waste;

2. Give utilities a fuel that is low in cost and sulfur content;

3. Conserve natural resources, while meeting energy needs;

4. Develop a large-scale application for solid waste as a useful material.

The current demonstration project is a continuation of a feasibility study and investigation for the "Use of Prepared Refuse with Coal in Large Utility Boilers." The investigators concluded that the concept was feasible if the refuse were shredded for use in a pulverized coal boiler with corner-fired burners. They also estimated that the refuse would constitute 10 percent of the total BTU load in the boiler. Ash slagging and corrosive effects of the use of a refuse-fuel mixture were pointed out as potential problems to be carefully studied during full-scale demonstration.

Based on information developed by the study and investigation, EPA awarded a grant to the City of St. Louis to demonstrate a full-scale facility. The Union Electric Company in that city has contributed monies and technical assistance to help the applicant. Initial consideration will be given to any effects the refuse may have on the boiler. Of primary concern are possible effects on the bottom ash, the boiler tubes, the air pollution control equipment, and the performance of the boiler. If it is established that the unit can handle the refuse without adverse effects, an optimum charging rate will be determined. The facility is capable of processing up to 720 tons of solid waste a day

and supplying up to 20 percent of the total heat load of the boiler.

The project is developed in two stages; a fuel processing stage and a boiler feeding stage. The solid waste is processed at a facility located on city property, which is near the sewage and incinerator plants. The waste is shredded and separated and is then hauled to a receiving bin at the powerplant. It is then conveyed to a storage bin and then pneumatically conveyed to the burners in the boiler.

All of the equipment has been installed and the system is being debugged. The facility has already processed up to 150 tons per 16-hour day during the week of May 8. The operation to date has been successful. Smoke from the stack was a little darker than normal, and small pieces of unburned materials were seen in the bottom ash. Union Electric seemed satisfied with the preliminary results. The components of the processing facility are illustrated in Figure 2. The refuse is discharged from packer-type trucks onto the floor of the receiving building where there is enough storage area for a two-shift operation. Front-end loaders push the raw refuse onto an inclined belt conveyor equipped with a belt scale. The belt conveyor, in turn, discharges onto a vibratory feeder, which feeds the hammermill.

Design specifications call for 45 tons of raw refuse to be fed into the hammermill (1,250 hp and 900 rpm motor), but momentary surges of up to 60 tons per hour will probably occur. An average of 360 tons is, therefore, expected to be processed in an eight-hour shift. To control dust produced by the milling operation, air will be drawn from the top of the feed hopper and discharged through a cyclone separator mounted on top of the feed hopper.

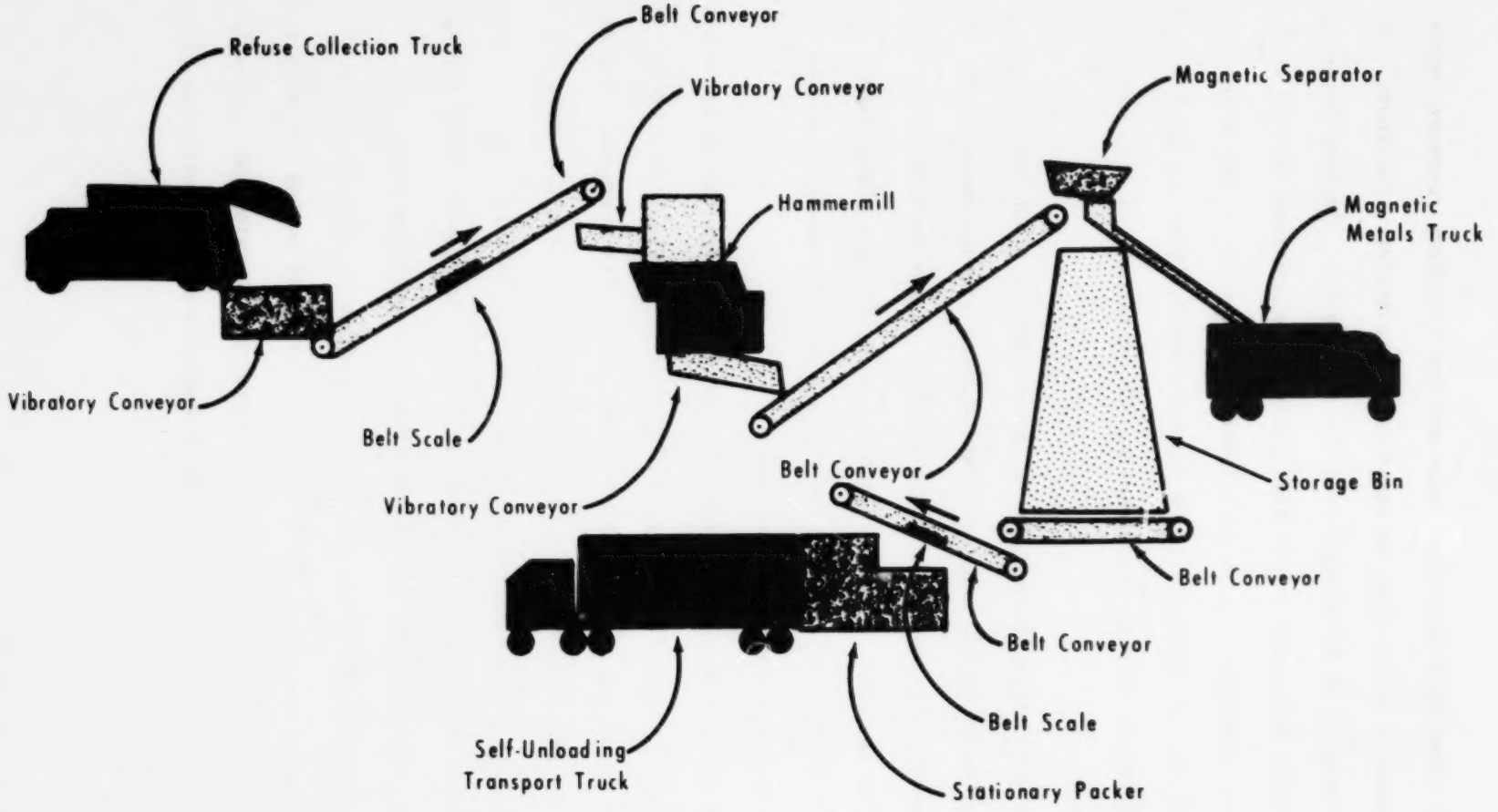

Figure 2: Components of the supplementary fuel processing facility in St.Louis.

The hammermill discharges onto another vibratory conveyor, which moves the pulverized refuse onto an inclined belt conveyor. The waste travels up this belt to be discharged into the storage bin. Ferrous materials are magnetically separated at the head pully and discharged through a chute to trucks for disposal. It is anticipated that between 5 and 10 percent by weight of the raw refuse will be magnetic metal. Whether the ferrous material can be sold is questionable. If it cannot, it will have to be landfilled.

The short-term storage bin at the processing plant has a gross volume of about 33,000 cubic feet and a gross storage capacity of approximately 300 tons. The sides have a 5 degree reverse slope to lessen the tendency of the milled material to bridge. Twin augers traverse the entire length of the bin and push the waste onto a horizontal belt conveyor along one side.

The milled refuse is discharged from the storage bin to an inclined belt conveyor which discharges to the hopper of a stationary packer similar to those in use at conventional raw refuse transfer stations. The stationary packer is used to fill self-unloading trailers that take the supplementary full 18 miles to the powerplant. Each trailer will be loaded with about 25 tons of material. At a 12.5 ton-per-hour firing rate, 12 loads per day is required from the processing plant.

The facilities at the powerplant are shown in Figure 3. The self-unloading mechanism of the transport trailers pushes the supplementary fuel into a receiving bin equipped with a twin-auger unloading device similar to that used in the storage bin at the processing plant.

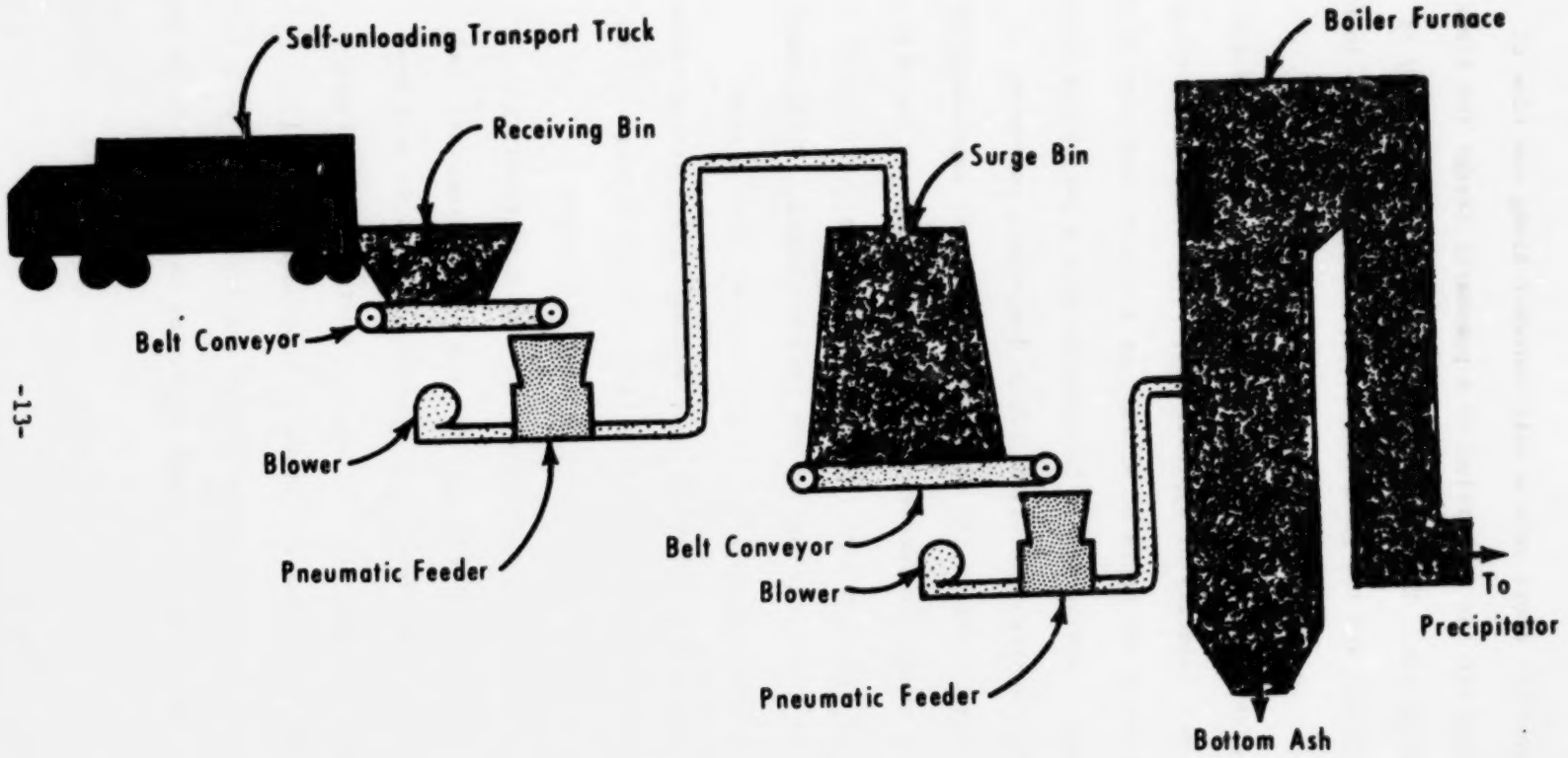

Figure 3: Flow of supplementary fuel through the Union Electric powerplant in St. Louis.

The material drops onto a belt conveyor along one side of the receiving bin and is carried to a pneumatic feeder for transfer to a surge bin. The bin unloader has a nominal capacity of 40 tons per hour and the pneumatic feeder has a capacity up to 60 tons per hour to ensure adequate transfer capacity.

The surge bin into which the pneumatic transfer system discharges, has a capacity of approximately 7,500 cubic feet, enough to provide about six hours of storage at a boiler feed rate of 12.5 tons per hour. The surge bin is circular with a peripheral chain-bucket type discharge mechanism. Four drag-chain conveyors installed under slots in the silo floor convey the supplementary fuel to four pneumatic feeders, each of which supplies the fuel to a burner port in the boiler furnace. Four burner ports are provided, one in each corner of the boiler furnace. Solid waste will be fired into the boilers 24 Hr/Day for 5 days a week.

It is anticipated that the electrostatic precipitator installed for air pollution control of the pulverized coal firing will be adequate for the combined firing of coal and refuse.

Actual capital and operating costs for this facility will be obtained. The estimated cost per ton of supplementary fuel is $5.29 for the 980 ton-per-day operation and $4.64 when processing 1,960 tons per day. These unit costs do not reflect any credit for the value of refuse as supplementary fuel. Whether a credit for the refuse can be realized depends on a number of factors, which should be answered during the next 12 to 18 months.

It appears that even without such a credit, both the overall operating and capital costs will not exceed and may be substantially less than those at many installations for conventional refuse incineration.

I wish to emphasize, quite strongly, that although I feel the two systems just described have a good deal of promise, they are not in my opinion ready for sale at the corner store. There is still much actual cost, operating and emission data to collect.

Perhaps most importantly, the systems must be put into full operation to face the everyday trials and tribulations that our currently abused conventional facilities have to cope with. However, I would recommend that you follow the progress of these projects to see where they lead.

The standards are tighter for these new facilities and we hope to prove that they are up to the task of meeting them BEFORE we confidently say they are true advanced techniques for incinerating solid waste.

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